Coal Market Module

The NEMS Coal Market Module (CMM) provides forecasts of U.S. coal production, consumption, exports, distribution, and prices. The CMM comprises three functional areas: coal production, coal distribution, and coal exports. A detailed description of the CMM is provided in the EIA publication, *Coal Market Module of the National Energy Modeling System 2003,* DOE/EIA-M060(2003) (Washington, DC, January 2003*).*

Key Assumptions

Coal Production

The coal production submodule of the CMM generates a different set of supply curves for the CMM for each year of the forecast. Separate supply curves are developed for each of 11 supply regions and 12 coal types (unique combinations of thermal grade, sulfur content, and mine type). The modeling approach used to construct regional coal supply curves addresses the relationship between the minemouth price of coal and corresponding levels of capacity utilization of mines, mining capacity, labor productivity, and the cost of factor inputs (mining equipment, mine labor, and fuel requirements).

The key assumptions underlying the coal production modeling are:

- Mining costs are assumed to vary with changes in capacity utilization of mines, mining capacity, labor productivity, and factor input costs. Factor input costs are represented by projections of electricity prices from the Electricity Market Module (EMM) and estimates of future coal mine labor and mining equipment costs.

- Between 1979 and 2001, U.S. coal mining productivity (measured in short tons of coal produced per miner per hour) increased at an estimated average rate of 6.2 percent per year. The major factors underlying these gains were interfuel price competition, structural change in the industry, and technological improvements in coal mining.[114] Based on the expectation that further penetration of certain more productive mining technologies, such as longwall methods and large capacity surface mining equipment, will gradually level off, productivity improvements are assumed to continue, but to decline in magnitude. Different rates of improvement are assumed by region and by mine type, surface and underground. On a national basis, labor productivity increases on average at a rate of 1.6 percent a year over the entire forecast, declining from an estimated annual rate of 2.4 percent between 2001 and 2010 to approximately 1.1 percent over the 2010 to 2025 period. These estimates are based on recent historical data reported on Form EIA-7A, *Coal Production Report*, and expectations regarding the penetration and impact of new coal mining technologies.[115]

- Between 1985 and 1993, the average hourly wage for U.S. coal miners (in 2001 dollars) declined at an average rate of 1.5 percent per year, falling from $22.63 to $20.09.[116] During this same time period the producer price index (PPI) for mining machinery and equipment (in 2001 dollars) declined by 0.6 percent per year, falling from 166.2 to 159.0.[117] In the reference case, both the wage rate for U.S. coal miners and mine equipment costs are assumed to remain constant in 2001 dollars (i.e., increase at the general rate of inflation) over the forecast. This assumption reflects the more recent trend in wages and mine equipment costs that has prevailed since 1993. In 2001, the average hourly wage rate for coal miners was $18.94, and the PPI for mining machinery and equipment was 157.8.

Coal Distribution

The coal distribution submodule of the CMM determines the least-cost (minemouth price plus transportation cost) supplies of coal by supply region for a given set of coal demands in each demand sector in each demand region using a linear programming algorithm. Production and distribution are computed for 11 supply and 16 demand regions for 21 demand subsectors.

The projected levels of industrial, coking, and residential/commercial coal demand are provided by the industrial, commercial, and residential demand modules; electricity coal demands are provided by the EMM, and coal export demands are provided from the CMM itself.

The key assumptions underlying the coal distribution modeling are:

- Base-year transportation costs are estimates of average transportation costs for each origin-destination pair. These costs are computed as the difference between the average delivered price for a demand region (by sector and for export) and the average minemouth price for a supply curve. Delivered price data are from Form EIA-3, *Quarterly Coal Consumption Report-Manufacturing Plants*, Form EIA-5, *Coke Plant Report-Quarterly*, Federal Energy Regulatory Commission (FERC) Form 423, *Monthly Report of Cost and Quality of Fuels for Electric Plants*, and the U.S. Bureau of the Census' Monthly Report EM-545. Minemouth price data are from Form EIA-7A, *Coal Production Report*.

Coal transportation costs are modified over time in response to projected variations in reference case fuel costs (No. 2 diesel fuel in the industrial sector), labor costs, the producer price index for transportation equipment, and a time trend. The transportation rate multipliers used for all five *AEO2003* cases are shown in Table 69.

Table 69. Transportation Rate Multipliers
(2001=1.000)

Year	Reference Case	High Oil Price	Low Oil Price	High Economic Growth	Low Economic Growth
2001	1.0000	1.0000	1.0000	1.0000	1.0000
2005	0.9661	0.9786	0.9647	0.9683	0.9664
2010	0.9304	0.9525	0.9189	0.9428	0.9222
2015	0.8739	0.8916	0.8598	0.9006	0.8566
2020	0.7954	0.8107	0.7810	0.8277	0.7703
2025	0.7487	0.7604	0.7339	0.7824	0.7143

Source: Energy Information Administration. Based on methodology described in "Forecasting Annual Energy Outlook Coal Transportation Rates", *Issues in Midterm Analysis and Forecasting 1997*, DOE/EIA-0607(97), (Washington, DC, July 1997).

- Electric generation demand received by the CMM is subdivided into "coal groups" representing demands for different sulfur and thermal heat content categories. This process allows the CMM to determine the economically optimal blend of different coals to minimize delivered cost, while meeting the sulfur emissions requirements of the Clean Air Act Amendments of 1990. Similarly, nongeneration demands are subdivided into subsectors with their own coal groups to ensure that, for example, lignite is not used to meet a coking coal demand.

Coal Exports

Coal exports are modeled as part of the CMM's linear program that provides annual forecasts of U.S. steam and metallurgical coal exports, in the context of world coal trade. The linear program determines the pattern of world coal trade flows that minimize the production and transportation costs of meeting a prespecified set of regional world coal import demands. It does this subject to constraints on export capacity and trade flows.

The CMM projects steam and metallurgical coal trade flows from 16 coal-exporting regions of the world to 20 import regions for three coal types (coking, bituminous steam, and subbituminous). It includes five U.S. export regions and four U.S. import regions.

The key assumptions underlying coal export modeling are:

- The coal market is competitive. In other words, no large suppliers or groups of producers are able to influence the price through adjusting their output. Producers' decisions on how much and who they supply are driven by their costs, rather than prices being set by perceptions of what the market can bear. In this situation, the buyer gains the full consumer surplus.

- Coal buyers (importing regions) tend to spread their purchases among several suppliers in order to reduce the impact of potential supply disruption, even though this adds to their purchase costs. Similarly, producers choose not to rely on any one buyer and instead endeavor to diversify their sales.

- Coking coal is treated as homogeneous. The model does not address quality parameters that define coking coals. The values of these quality parameters are defined within small ranges and affect world coking coal flows very little.

Data inputs for coal export modeling:

- U.S. coal exports are determined, in part, by the projected level of world coal import demand. World steam and metallurgical coal import demands for the *AEO2003* forecast cases are shown in Tables 70 and 71.

Table 70. World Steam Coal Import Demand by Import Region, 2001-2025
(Million metric tons of coal equivalent)

Import Regions[1]	2001	2005	2010	2015	2020	2025
The Americas	38.5	36.7	40.2	42.2	44.8	44.5
United States	15.7	13.5	16.0	18.5	21.0	23.5
Canada	15.0	11.2	10.1	9.4	9.1	5.6
Mexico	2.1	6.0	6.4	6.6	7.0	7.7
South America	5.7	6.0	7.7	7.7	7.7	7.7
Europe	132.5	133.5	137.4	130.3	126.3	122.4
Scandinavia	11.7	8.4	5.6	4.3	3.6	2.9
U.K/Ireland	25.1	24.1	22.1	18.5	16.7	16.7
Germany/Austria	15.4	17.9	21.5	22.4	24.2	26.0
Other NW Europe	24.1	23.0	20.6	16.2	12.6	9.0
Iberia	19.4	25.3	27.4	26.4	24.7	22.9
Italy	11.4	8.6	8.2	7.7	7.3	6.8
Med/E Europe	25.4	26.2	32.0	34.8	37.2	38.1
Asia	195.0	226.1	261.6	279.0	296.1	311.9
Japan	75.2	83.3	96.0	101.5	106.9	112.3
East Asia	84.3	94.3	106.1	109.7	113.3	117.9
China/Hong Kong	9.8	9.7	14.5	19.0	23.6	25.4
ASEAN	15.5	23.9	28.5	30.5	32.2	33.5
Indian Sub	10.2	14.9	16.5	18.3	20.1	22.8
Total	366.0	396.3	439.2	451.5	467.2	478.8

[1]Import Regions: **South America:** Argentina, Brazil, Chile; **Scandinavia:** Denmark, Finland, Norway, Sweden; **Other NW Europe:** Belgium, France, Luxembourg, Netherlands; **Iberia:** Portugal, Spain; **Med/E Europe:** Algeria, Bulgaria, Croatia, Egypt, Greece, Israel, Malta, Morocco, Romania, Tunisia, Turkey; **East Asia:** North Korea, South Korea, Taiwan; **ASEAN:** Malaysia, Philippines, Thailand; **Indian Sub:** Bangladesh, India, Iran, Pakistan, Sri Lanka.

Notes: One “metric ton of coal equivalent” contains 27.78 million Btu. Totals may not equal sum of components due to independent rounding.

Source: Projections: Energy Information Administration, Office of Integrated Analysis and Forecasting; and SSY Consultancy and Research, “Data Updates for the International Coal Trade Component of the National Energy Modeling System”, June 1999.

- Step-function coal export supply curves for all non-U.S. supply regions. The curves provide estimates of export prices per metric ton, inclusive of minemouth and inland freight costs, as well as the capacities for each of the supply steps.

Table 71. World Metallurgical Coal Import Demand by Import Region, 2001-2025
(Million metric tons of coal equivalent)

Import Regions[1]	2001	2005	2010	2015	2020	2025
The Americas	20.6	22.3	24.7	27.5	30.0	29.9
United States	2.1	2.0	1.8	1.7	1.5	1.4
Canada	3.9	4.0	3.9	3.7	3.5	3.4
Mexico	1.1	1.3	2.3	2.9	3.8	3.9
South America	13.5	15.0	16.7	19.2	21.2	21.2
Europe	53.4	53.3	52.9	51.4	49.6	49.1
Scandinavia	3.3	2.8	2.8	2.8	1.8	1.6
U.K/Ireland	10.4	7.7	7.7	7.2	7.2	7.2
Germany/Austria	3.6	6.4	7.0	7.0	7.0	7.0
Other NW Europe	16.6	15.2	13.4	12.4	11.4	10.9
Iberia	4.4	4.5	3.9	3.9	3.9	3.9
Italy	8.6	7.3	7.2	6.4	6.4	6.4
Med/E Europe	6.5	9.4	10.9	11.7	11.9	12.1
Asia	109.0	109.4	109.4	111.7	113.5	116.3
Japan	69.2	63.5	59.6	58.2	56.7	54.8
East Asia	25.6	28.1	31.4	33.4	35.7	37.6
China/Hong Kong	0.0	0.6	0.6	0.6	0.6	0.6
ASEAN	0.0	0.0	0.0	0.0	0.0	0.0
Indian Sub	14.2	17.2	17.8	19.5	20.5	23.3
Total	183.0	185.0	187.0	190.6	193.1	195.3

[1]Import Regions: **South America:** Argentina, Brazil, Chile; **Scandinavia:** Denmark, Finland, Norway, Sweden; **Other NW Europe:** Belgium, France, Luxembourg, Netherlands; **Iberia:** Portugal, Spain; **Med/E Europe:** Algeria, Bulgaria, Croatia, Egypt, Greece, Israel, Malta, Morocco, Romania, Tunisia, Turkey; **East Asia:** North Korea, South Korea, Taiwan; **ASEAN:** Malaysia, Philippines, Thailand; **Indian Sub:** Bangladesh, India, Iran, Pakistan, Sri Lanka.

Notes: One "metric ton of coal equivalent" contains 27.78 million Btu. Totals may not equal sum of components due to independent rounding.

Source: Projections: Energy Information Administration, Office of Integrated Analysis and Forecasting; and SSY Consultancy and Research, "Data Updates for the International Coal Trade Component of the National Energy Modeling System", June 1999.

- Ocean transportation rates (in dollars per metric ton) for feasible coal shipments between international supply regions and international demand regions. The rates take into account maximum vessel sizes that can be handled at export and import piers and through canals and reflect route distances in thousand nautical miles.

Coal Quality

Each year the values of base year coal production, heat, sulfur and mercury (Hg) content and carbon dioxide emissions for each coal source in CMM are calibrated to survey data. Surveys used for this purpose are the FERC Form 423, a survey of the origin, cost and quality of fossil fuels delivered to electric utilities, the Form EIA 860B which records the quality of coal consumed at independent power producers, the Form EIA5 and 5a which record the origin, cost, and quality of coal receipts at domestic coke plants, and the Forms EIA 3 and 3a, which record the origin, cost and quality of coal delivered to domestic industrial consumers. Estimates of coal quality for the export and residential/commercial sectors are made using the survey data for coal delivered to coking coal and industrial steam coal consumers. Hg content data for coal by supply region and coal type, in units of pounds of Hg per trillion Btu in Table 72, were derived from shipment-level data reported by electricity generators to the Environmental Protection Agency in its 1999 Information Collection Request. The database included approximately 40,500 Hg samples reported for 1,143 generating units located at 464 coal-fired facilities. Carbon dioxide emissions levels for each coal type are listed in Table 68 in pounds of carbon dioxide emitted per million Btu.[118]

Legislation

It is assumed that provisions of the Energy Policy Act of 1992 that relate to the future funding of the Health and Benefits Fund of the United Mine Workers of America will have no significant effect on estimated production costs, although liabilities of company's contributions will be redistributed. Electricity sector demand for coal, which represented 91 percent of domestic coal demand in 2001, incorporates the provisions of the Clean Air Act Amendments of 1990. It is assumed that electricity producers will be granted full flexibility to meet the specified reductions in sulfur dioxide emissions. The reference case excludes any potential environmental actions not currently mandated such as mercury reductions or other rules or regulations not finalized.

Mining Cost Cases

In the reference case, labor productivity is assumed to increase at an average rate of 1.6 percent per year through 2025, while wage rates and mine equipment costs remain constant in 2001 dollars. Two alternative cases were modeled in the NEMS CMM, assuming different growth rates for both labor productivity and miner wages. In a low mining cost sensitivity case, productivity increases at 3.1 percent per year, and real wages and mine equipment costs decline by 0.5 percent per year. In a high mining cost sensitivity case, productivity increases by 0.1 percent per year, and real wages and mine equipment costs increase by 0.5 percent per year. In the alternative cases, the annual growth rates for productivity were increased and decreased by mine type (underground and surface), based on historical variations in labor productivity. Both cases were run as fully integrated NEMS runs.

Table 72. Production, Heat Content, and Sulfur, Mercury and Carbon Dioxide Emissions by Coal Type and Region

Coal Supply Region	States	Coal Rank and Sulfur Level	Mine Type	2000 Production (Million Short tons)	Heat Content (Million Btu per Short Ton)	Sulfur Content (Pounds Per Million Btu)	Mercury Content (Pounds Per Trillion Btu)	CO2 Emissions (Pounds Per Million Btu)
Northern Appalachia	PA, OH, MD, WV (North)	Metallurgical	Underground	4.7	27.43	0.74	N/A	205.4
		Low-Sulfur Bituminous	All	0.4	26.06	0.51	11.62	203.6
		Mid-Sulfur Bituminous	All	72.7	25.54	1.22	11.16	205.4
		High-Sulfur Bituminous	All	61.4	24.28	2.41	11.67	203.6
		Waste Coal (Gob and Culm)	Surface	10.1	12.44	1.72	63.90	203.6
Central Appalachia	KY(East), WV (South), VA	Metallurgical	Underground	47.2	27.43	0.55	N/A	203.8
		Low-Sulfur Bituminous	All	65.9	25.16	0.55	5.61	203.8
		Mid-Sulfur Bituminous	All	145.3	24.94	0.81	7.58	203.8
Southern Appalachia	AL, TN	Metallurgical	Underground	6.8	27.43	0.40	N/A	203.3
		Low-Sulfur Bituminous	All	6.0	25.02	0.56	3.87	203.3
		Mid-Sulfur Bituminous	All	9.1	24.53	1.08	10.15	203.3
East Interior	IL, IN, KY (West), MS	Mid-Sulfur Bituminous	All	30.9	23.02	1.13	5.60	202.8
		High-Sulfur Bituminous	All	56.3	22.78	2.76	6.35	202.5
		Mid-Sulfur Lignite	Surface	0.6	10.59	1.10	14.11	211.4
West Interior	IA, MO, KS, AR, OK. TX (Bit)	High-Sulfur Bituminous	Surface	2.4	22.32	2.59	21.55	202.4
Gulf Lignite	TX (Lig), LA	Mid-Sulfur Lignite	Surface	36.4	12.94	1.32	14.11	211.4
		High-Sulfur Lignite	Surface	16.6	12.67	2.18	15.28	211.4
Dakota Lignite	ND, MT(Lig)	Mid-Sulfur Lignite	Surface	31.6	13.23	1.08	8.38	216.6
Powder River, Green River, and Hannah Basins	WY, MT(Sub)	Low-Sulfur Subbituminous	Surface	345.7	17.51	0.34	5.68	210.7
		Mid-Sulfur Subbituminous	Surface	29.9	17.61	0.78	5.82	210.7
		Low-Sulfur Bituminous	Underground	1.2	21.93	0.51	2.08	204.4
Rocky Mountain	CO, UT	Low-Sulfur Bituminous	Underground	46.6	23.46	0.40	3.82	203.0
		Low-Sulfur Subbituminous	Surface	9.2	20.70	0.41	2.04	210.6
Southwest	AZ, NM	Low-Sulfur Bituminous	Surface	19.6	21.37	0.46	4.66	205.4
		Mid-Sulfur Subbituminous	Surface	20.8	18.52	0.88	7.18	206.7
		Mid-Sulfur Subbituminous	Underground	*	19.80	0.88	7.18	206.7
Northwest	WA, AK	Mid-Sulfur Subbituminous	Surface	5.9	16.32	0.85	6.99	207.9

*Indicates that quantity is less than 50,000 short tons.

N/A = not available.

Source: Energy Information Administration, Form EIA-3, “Quarterly Coal Consumption Report—Manufacturing Plants”; Form EIA-3A, “Annual Coal Quality Report—Manufacturing Plants”; Form EIA-5, “Coke Plant Report Quarterly”; Form EIA-5A, “Annual Coal Quality Report—Coke Plants”; Form EIA-860B, “Annual Electric Generator Report—Nonutility”; Form EIA-6A, “Coal Distribution Report—Annual”; and Form EIA-7A, “Coal Production Report.” Federal Energy Regulatory Commission, Form 423, “Monthly Report of Cost and Quality of Fuels for Electric Plants.” U.S. Department of Commerce, Bureau of the Census, “Monthly Report EM-545.” U.S. Environmental Protection Agency, Emission Standards Division, *Information Collection Request for Electric Utility Steam Generating Unit, Mercury Emissions Information Collection Effort* (Research Triangle Park, NC, 1999). B.D. Hong and E.R. Slatick, “Carbon Dioxide Emission Factors for Coal,” in Energy Information Administration, *Quarterly Coal Report*, January-March 1994, DOE/EIA-0121 (94/Q1) (Washington, DC, August 1995).

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